A Proposed Methodology to Classify Frontier Capital Markets

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14. ABSTRACT

This project involves basic research to understand the network structure and process required to accelerate the growth of Frontier Capital Market Status as the first step to access global investment. Global investment encouraged by the presence of efficient capital markets can promote stability in a region and reduce the potential for, and duration of, military intervention. Using a network-based approach to evaluate Frontier Market development and stability, we are discovering underlying metrics that describe the market state. Through large-scale quasi-experiments, we are modeling how Frontier Markets succeed or fail. This research will provide quantitative analysis to senior decision makers engaged in shaping economic development policy.

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"The success of our economy has always depended not just on the size of our gross domestic product, but on the reach of our prosperity; on the ability to extend opportunity to every willing heart -- not out of charity, but because it is the surest route to our common good."

-Inaugural Speech by President Barack Obama, Jan 2009

This project involves basic research to understand the network structure and process required to accelerate the growth of Frontier Capital Markets. In an undeveloped economy, achievement of Frontier Market status is the first step to attain access to global investment[1]. Global investment encouraged by the presence of efficient capital markets can promote stability in a region and reduce the potential for, and duration of, military intervention. Using a network-based approach to evaluate Frontier Market development and stability, we are discovering underlying metrics that describe the market state. Through large-scale quasi-experiments, we are modeling how Frontier markets succeed and fail. This research will provide quantitative analysis to senior decision makers engaged in shaping economic development policy.

Our research team comprising West Point faculty from the Network Science Center, the Department of Mathematics, the Department of Social Sciences, and West Point cadets is developing an innovative, network analysis-based methodology for modeling complex networks; in this case, Capital Markets by assigning each capital market a classification, or topology. This topology will identify the influential nodes (agents, organizations, or roles) that exist within each capital market network. This

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[1] The bond rating agency, Standard and Poor's, categorizes markets as Frontier, Emerging or Developed. Frontier Markets have the minimum qualities required to be tracked and participated in by standard market investors.

analysis can alert policymakers to important changes in the network's state as well as predict the potential impact of network changes. Additionally, this approach can allow decision makers to influence the network by highlighting "driver nodes," the nodes in the network that have the greatest probability of affecting a desired outcome. We envision that this methodology can facilitate development of a playbook for evaluating other complex networks such as intelligence or foreign policy networks.

Figure 1: Study Concept
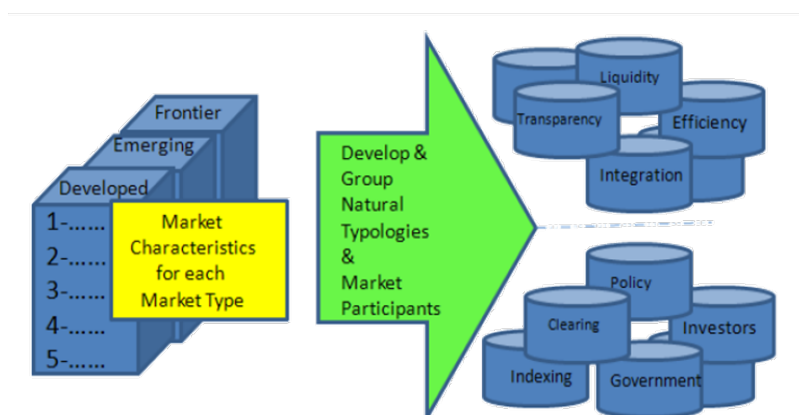
Frontier Markets

Initial research efforts focus on Frontier Capital Markets. Financial analysts typically classify capital markets into three broad categories: Developed, Emerging, and Frontier. Several organizations publish proprietary classifications, and each has slightly different quantitative and qualitative classification criteria. Frontier Markets countries include the smallest, less developed, less liquid markets that make up investable markets in the developing world. Countries with low to middle income levels as defined by the World Bank are generally considered "emerging;" however, issues such as the level of market development, transparency, and economic reforms are also important factors. Examples of established Frontier Markets include Botswana, Bulgaria, Croatia, Kazakhstan, Nigeria, Sri Lanka and Vietnam.

Unlike Developed and Emerging Markets, Frontier Markets have a smaller scope and fewer formal institutional controls. In such markets, social relations and human behavior have a greater impact than in well-developed capital markets controlled by established rules and regulations. For this reason, the study of Frontier Capital Markets provides a unique opportunity for understanding the network-based intersection of human behavior and economics. The individual motivations, information availability, transaction systems, and cultural realities in these markets provide a context with rich complexity. Thus, a social network analysis approach reveals interesting insights into interrelationships among individual actors and organizations and how these markets operate and evolve, and thus contribute to economic development. Disclosure requirements for organizations operating within these capital markets allow researchers to identify members, subordinate organizations and intermediaries, which provide researchers with a rich data set of network nodes, relationships and attributes.

Network Analysis and Economics

We propose that some techniques pioneered by Network Scientists combined with this innovative methodology can assist policymakers in developing more effective plans for economic development. Economists are beginning to embrace the idea that new models need to be developed to address the "networked" environment of economics and finance. Alan Kirman, a professor at Cezanne University in Marseilles, is a leading proponent of this movement. In a 2010 paper, he argues that individuals don't behave according to microeconomic principles and the attempt to aggregate these "separate" principles is a problem. Additionally, he argues that "The homo economicus is not an accurate or adequate description of human decision making," and he questions such common economic assumptions such as representative agent, stability and uniqueness of equilibria, individual rationality, information availability, and an anonymous market.[2]

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[2] Kirman, Alan. "The Economic Crisis is a Crisis for Economic Theory," CESifo Economic Studies, Vol. 56, 4/2010, 498 – 535, Oxford, Oxford University Press.

The recent financial crisis of 2008 offers a bleak illustration. Financial institutions, acting individually, to maximize their returns and minimize risk, spread increasingly complex financial instruments throughout the financial system thereby destabilizing it. The highly interdependent network of financial institutions that evolved was not predicted or explained by traditional economic models, resulting in the near collapse of the entire system. Kirman suggests that macroeconomic theory needs to incorporate the network of interacting individuals, the structure of their interactions, and the consequences of network activity.[3]

Network analysis can inform behavioral, financial and development economists seeking to understand the essential characteristics that foster capital market development in countries where social capital can be as important as financial capital. As Stiglitz and Gallegati (2011) note, "Some network designs may be good at absorbing small shocks, when there can be systemic failure when confronted with a large enough shock. Similarly, some typologies may be more vulnerable to highly correlated shocks."[4] Goyal (2007) found that, "Network structure has significant effects on individual behavior and on social welfare." He concluded that some networks are better than others to promote socially desirable outcomes, and both the quality and quantity of the links in the networks are important.[5] Understanding the personal, corporate, and information networks that underlie capital markets in developing economies is a critical component for developing programs that foster economic growth, expand economic opportunities, and mitigate risk.

The majority of the previous study involving network analysis and economics has focused on micro-economic theory with a general emphasis on decision-making, individual behavior, and game theory. Network scientists have also delved into such topics as viral marketing and the economics of network-valued commodities. Some work has been done at the macro level focusing on international relations and trade, but

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[3].Ibid.

[4] Stiglitz, Joseph E. and Mauro Gallegati, "Heterogeneous Interacting Agent Models for Understanding Monetary Economics," *Eastern Economic Journal*, Volume 37, Winter 2011, pp. 6-12, Bloomsburg, PA, Eastern Economic Association.

[5] Goyal, Sanjeev (2007). Connections: An Introduction to the Economics of Networks, Princeton: Princeton University Press, pp. 54, 27.

increasingly researchers are recognizing the need to incorporate a network approach to enhance our understanding of macro markets, especially capital markets. Individuals make economic decisions in a market context that is influenced by their social interactions and opportunities. Examining the structure, dynamics, and unique characteristics of the capital market network in which they operate is vital to developing a better understanding of how capital markets evolve.

Economic analysis and prediction is further complicated in developing economies where individuals make reciprocal exchanges and clan or family interests are as important, or maybe more important than individual self-interest. Other important considerations are the social norms, institutions and legal frameworks within which individuals operate. Furthermore, information asymmetry and insufficient contract enforcement can limit the willingness of creditors and investors to provide critical investment funds. We expect our network approach to discover existing qualities of market behavior that do not adhere to traditional economic models. This research is important not only because of the insight it adds to network science, but also because it will broaden our understanding of the critical factors affecting market development.

The Role of Capital Markets in Economic Development

Economies experience real growth at the individual firm level. In order to grow, companies require capital to expand operations, develop new products and services, and construct facilities. It is recognized that well-functioning financial markets are associated with economic growth. Levine and Zevros (1996) found that developed capital markets are correlated with improved economic performance, and there is a link between the size and liquidity of stock markets and easy access to information, rigorous accounting standards, and strong investor protections.[6]

Domestic and international investment in developing economies is vital for economic development. However, few investors are willing to participate in a capital

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[6] Levine, Ross and Sara Zervos (1996), "Stock Market Development and Long Run Growth," *World Bank Economic Review*, Vol. 10, No. 2.

market unless they know they can sell their shares easily in markets that are both liquid and well regulated. The ability to buy and sell equity or debt on demand at a reasonable price is a key milestone in the development of a well-functioning capital market. Liquid markets have many buyers and sellers, relatively small spreads between buying and selling prices, and robust trading volumes. Additionally, investors require transparency – reliable information about a firm's financial condition, profitability, forecasts, share prices, and management. Government stability, economic policies, taxation, and the ability to repatriate capital influence an investor's perception of the political risk of an investment and consequently, the risk premium required.

In his research on African financial markets, Ndikumana (2001) found that market structure evolves to fit the country's income level.[7] In undeveloped economies, buyers and sellers exchange goods and services in barter transactions. As economies develop, banks often become the primary institutions that allocate funds from depositors to businesses and individuals with credit-worthy projects. As businesses mature and seek to expand, demand for capital fuels the development of capital markets to efficiently allocate savings to investment. Financial intermediaries help to identify the optimal investment options, improve information asymmetries, and monitor corporate management behavior.[8]

In order to promote economic development and growth, policymakers need to assist in the development of well-functioning capital markets yet, a recent study of United States Government development efforts notes, "… in many ways, in fact, the United States has yet to develop a coherent or effective approach to economic development… The environment for such efforts is often a dizzying mosaic of organizations and countries plagued by misaligned – or even contrarily aligned – incentives, both among themselves and with the host nation." [9]

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[7] Ndikumana, Leonce (2001). "Financial Markets and Economic Development in Africa," PERI Working Paper 17, Political Economy Research Institute, Amherst: University of Massachusetts.
[8] Ndikumana (2001), p. 26.
[9] Patterson, Rebecca and Dane Stangler, "Building Expeditionary Economics: Understanding the Field and Setting Forth a Research Agenda," *Kauffman Foundation Research Series: Expeditionary Economics*, Kansas City, MO: Ewing Marion Kauffman Foundation, November 2010, p. 6.

Successful economic development requires that small and medium firms have access to the capital necessary for business development but currently little is understood about the structure and functions of capital markets in the world's less-developed countries. We propose that this classification methodology will provide a rigorous, quantitative tool that will allow policymakers to customize economic development strategies based on network typologies and the identification of driver nodes.

Frontier Markets Network Analysis

The objective of this initial research effort is to develop an innovative, quantitatively based methodology to classify Capital Markets. This methodology could serve as the building block for developing typology classifications for myriad types of networks, be they social, physical, or biological. Our team has identified four distinct pillars that will be integrated into a Capital Market Network Classification Model. The pillars incorporate a Capital Markets Social Network and Functional Network Model, a Macroeconomic Variables Classification Algorithm, a Social Capital Model, and a Capital Flow Network that maps financial flows through the market. We will analyze network data using these four approaches and identify quantitative metrics associated with different network classifications. We will then classify the capital markets studied based on this new Network Classification Model. The four analytic frameworks are discussed in detail in the following Network Classification Model section.

The Research Team is developing models of the following three Frontier Capital Markets: Ghana, Tanzania, and Trinidad and Tobago. After comparing and contrasting each capital market based on the Network Classification Model, we will quantitatively determine the similarities and differences "horizontally" across these three capital markets. The team will then analyze an Emerging Market in order to conduct a "vertical" comparison and determine, quantitatively, the difference between the three Frontier Markets and the selected Emerging Market. We selected the capital market in Prague, Czech Republic because it was established at the same time as many Frontier

Markets (mid-1990s) but has become a very active market with much greater liquidity than most Frontier Markets. Such a comparison will reveal similarities and differences in the network structure of developing versus emerging markets furthering our understanding of the types of networks that have fostered more efficient and effective capital markets as well as economic growth.

Network Classification Model

1. Capital Market Functional Network

Initial research, including in-country interviews, indicated that each of the three capital markets has very distinct network characteristics based on history, geography, and culture. In order to model these characteristics, researchers collected extensive data about the individual actors in the network, using mathematical techniques to identify and evaluate the agents and organizational nodes in the network. Initially focusing on key stock exchange personnel and government regulators, the network expanded to include key personnel in publicly-traded companies, banks, brokerage firms, government, the military, key associations (such as CEO roundtables or industrial trade groups), and parastatal organizations, organizations that are indirectly controlled by the government such as the Unit Trust of Tanzania, a mutual fund.

For each entity selected, we conducted Internet research on key personnel, such as chief executives and board members, and recorded individual résumé data such as the organizations with which they were currently or had previously been associated. The organizations listed comprised both publicly traded and private firms in addition to clubs and professional associations. The team also collected data on nationality, educational attainment, university affiliations, and teaching expertise and then conducted interviews with key participants in the stock exchanges, banks, brokerage firms, and government whom the initial models indicated were hubs in the network.

Figure 1: Social Network Development
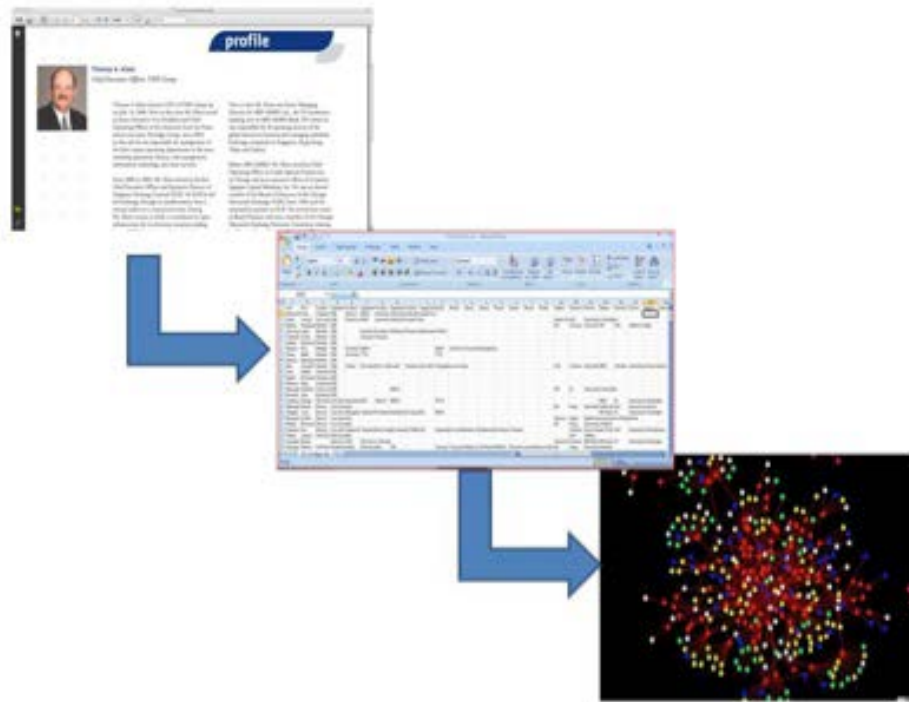
After reviewing an individual's résumé data, researchers identified and recorded up to three functions that best described their areas of specialization within the network. The functions ranged from commercial banking to conglomerate to parastatal. Using network analysis software developed by the Center for Computational Analysis of Social and Organizational Systems at Carnegie Mellon University, Organizational Risk Analyzer (ORA),[10] the team constructed networks for each country that associated people with functions. Then, utilizing Matrix Algebra, we produced a network that describes how functions are connected with other functions through individuals. ORA generated descriptive statistics and structures or typologies of each network such as the following Ghana functional network.

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[10] Carley, Kathleen M. (2001-2010). ORA: Organizational Risk Analyzer v.2.02. [Network Analysis Software]. Pittsburgh: Carnegie Mellon University.

Figure 2: Ghana Functional Network Visualization
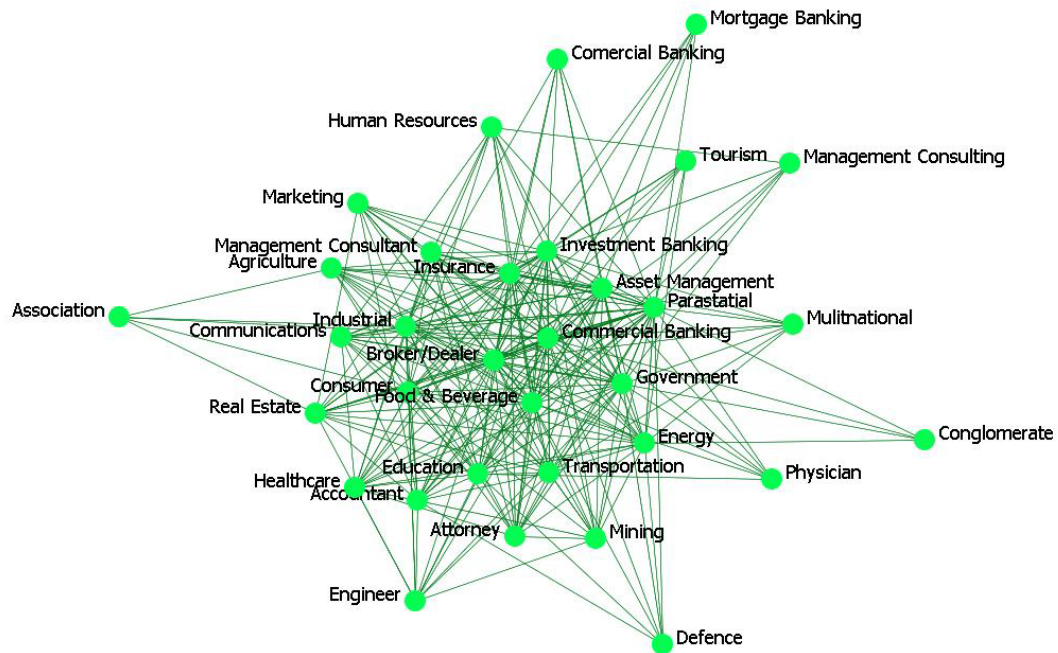
Graphical representations such as these help identify clusters in the network and then allow researchers to drill down into the composition of the clusters. Quantitative network measures, such as closeness, betweenness, and centrality, provide insights into the various roles and groups in a network such as which nodes are the connectors, mavens, leaders, bridges, and isolates. Trust and information sharing are vital for capital markets to operate effectively. Capital market network typologies reveal how actors in the network are connected and enable us to identify the individuals and organizations that serve as central hubs and power brokers – connecting other individuals and sharing information in the network. They also identify potential points of failure and which individuals and organizations are on the shortest paths between nodes and exhibit the most influence on other nodes. Additionally, network analysis reveals which individuals or organizations are on the periphery of the network, lacking information or resources. These network typologies also enable researchers to classify, compare and contrast capital market networks.

2. Macroeconomic Metrics

Our team has developed in innovative algorithm that has achieved success as a classifier mechanism in initial tests. This type of mechanism is used for automated prediction, identification, and machine learning. The algorithm consists of a unique binary classifier mechanism that combines three methods: k-Nearest Neighbors (kNN), ensemble creation, and Bayesian probability. The team will gather macroeconomic metrics for a variety of Developed, Emerging, and Frontier markets and then classify the capital markets based on this novel quantitative approach.

Each classifier is tailored to detecting membership in a specific class using a best subset selection process. This approach provides the diversity needed to successfully implement an ensemble. Ensembles increase classification strength by using the collective output of several classifiers instead of a single methodology. The resulting vectors are translated into ensemble classifiers. Then conditional probability is applied to the ensemble classification methodology, which improves the accuracy where an input might result in multiple positive classifications. The binary nature of the classification algorithm is very useful when choosing how to evaluate and weight information in a conflicted and incomplete network environment. One of the challenges in network science is selecting the most important decision variables from extensive datasets. This algorithm identifies complex underlying mathematical relationships in order to make classification decisions.

3. Social Capital Model

Social Capital is generally defined as an economic concept that evaluates the connections between individuals and entities. Edwards (2002) states, that social capital is "integrally related to other forms of capital, such as human (skills and qualifications), economic (wealth), cultural (modes of thinking), and symbolic (prestige and personal qualities). For example, economic capital augments social capital, and cultural capital can be readily translated into human and social capital."[11]

Social networks that include people who trust and assist each other can be a powerful asset. These relationships between individuals and firms can lead to a state in which each will think of the other when something needs to be done. Along with economic capital, social capital is a valuable mechanism in economic growth. The concept of Social Capital can be used to model and differentiate a network that takes into account elements of culture, society, and history. Social Capital is an easy concept to understand but it is notoriously hard to quantify. In the research on the social capital of individuals, there has been little standardization of measurement instruments, and more emphasis on measuring social relationships than on social resources.[12]

The team has developed an original and elegant survey, based on the Resource Generator Model work of van Der Gaag and Snijders,[13] which researchers will use to quantify the concept of Social Capital. Table I below contains sample survey questions used to collect data on Social Capital in different capital markets. This methodology enables measurement of both the breadth and depth of different aspects of Social Capital. The data collected also allows the team to generate insightful regression models and to horizontally compare the Social Capital of each specific Capital Market of interest. Initial data collection has produced encouraging preliminary results. Based on

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[11] Edwards, R. (2002). Social capital, A Sloan work and family encyclopedia entry. Chestnut Hill, MA; The Sloan Work and Family Research Network.

[12] Van Der Gaag & Snijders (2004) The Resource Generator: Social capital quantification with concrete items. Free University Amsterdam & University of Groningen.

[13] Ibid.

these early successes, the team is aggressively collecting data in our countries of interest and will be refining the models accordingly.

Table I: Sample Social Capital Survey Questions

*We define **acquaintances** as people whom you recognize by site on the street and could start a conversation with, and **friends** are people with whom you have contact at least every two weeks.* Keeping this in mind, **How many people do you know that you could ask for help who:**

	Family	Friends	Acquaintances
Has good contacts with the media			
Owns a vacation home			
Earns more than $500 per month			
Graduated college			
Is active in a political party			
Knows about government regulations			
Knows about financial matters			
Could loan you enough money to buy a home			
Has gotten a loan from a bank before			
Invests in stocks and bonds			

4. Capital Flows Model

The team is developing an innovative network model that addresses the actual flow of capital throughout the Capital Markets studied. This network will also take into account external and internal constraints and limitations. It models how funds deployed by a foreign investor in the Frontier or Emerging Markets of interest would flow throughout the financial system. The research team will develop a network that addresses the market's trading system, clearing process, and depository system.

13

Additionally, the team will address the legal and regulatory constraints and limitations inherent in the capital market. For example, in some markets, legal limits exist on the amount of equity foreign investors are allowed to purchase.

The Capital Flows Network will also consider the types of assets that are available in specific capital markets, transaction costs, and trading options. For example, the most liquid and efficient capital markets in the world allow investors to participate in numerous ways with fairly low transactions costs. Examples of the types of assets that trade in large volumes on these liquid markets are corporate bonds, options, futures, and derivative products.

This Capital Flows model will allow our team to accurately describe a vital aspect of Capital Markets that was observed during visits to our countries of interest. The ease and ability to move funds in and out of a market is an essential component of a healthy market. In Frontier Markets, it is often very difficult to deploy funds due to regulations and local constraints. The method in which capital is actually deployed in a Capital Market is an extremely important component of the efficiency, transparency, and liquidity of the overall market. If institutional and retail investors perceive this process to be flawed, they will be less likely to participate in the market. A positive perception of market operations is necessary in order to encourage foreign direct investment.

Future Plans and Further Applications

Future research will focus on completing the "horizontal" comparison between the Frontier Capital Markets and the Emerging Market Model. The team will refine the methodology to classify and compare financial networks and the Social Capital Survey and Model. Based on our lessons learned, researchers will conduct another round of Social Capital surveys in the designated Frontier Markets. The final classification model will enable the team to expand its efforts beyond basic science to real-world applications. This model will provide U.S. Government, Military, and Non-Governmental

Organizations with a playbook when creating economic development plans in the future. It will also provide vital information to organizations from the national level to the district or village-level and inform decision-makers about the network structure allowing them to focus on aspects of the network that will generate more efficient and effective results. An example of this collaboration is a proposed link to an existing project supporting Agricultural Development Teams that are deployed worldwide by the U.S. Army National Guard. These teams are uniquely qualified to gather data in the course of their work that will assist in the development of network classifications or typologies that can inform members of other U.S. Government and even Non-Governmental Organizations. Furthermore, we will be involved in a research effort to study the quantitative measures that determine the evolving state of a network. The collaboration will explore the potential to quantitatively determine if a financial network has changed state and if this is a vital piece of intelligence for the U.S. Government.

Over the course of the next year, we plan to publish on the following topics.

A. Study Methodology: Lessons Learned and Comparisons to Current Economic Modeling
B. Developing Macro-level Models of Capital Markets: Proposing New Network-Based Macroeconomic Models for Comparing Capital Markets
C. Measuring Social Capital: Utilizing the Resource Generator Model in Frontier Capital Markets to Develop Network Typologies
D. Classifying Capital Markets Based on Macro-Economic Variables: Automated Decision Support Through kNN Ensemble Classification Techniques
E. Capital Market Classification Based on Capital Flows and Trading Architecture
F. Horizontal Comparative Results: Developing a Framework for Horizontal Comparison
G. Vertical Comparison of Frontier Capital Markets with Emerging Capital Markets

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